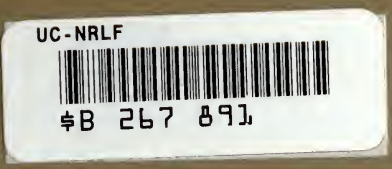

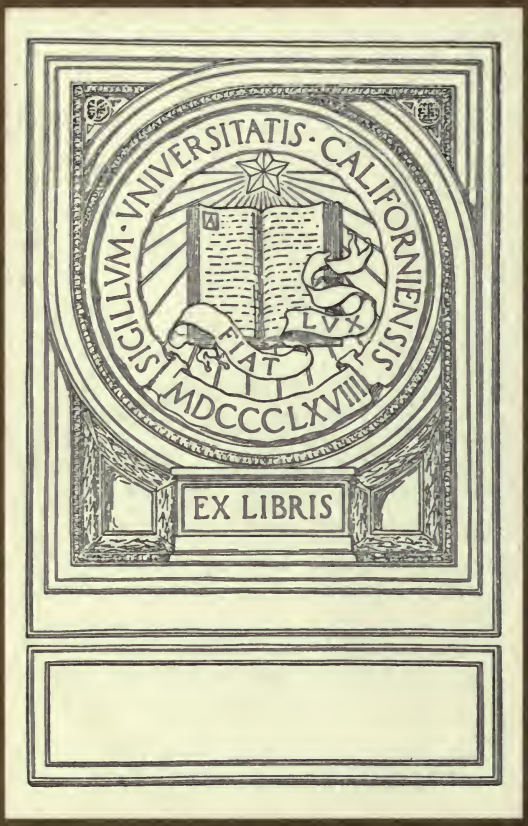
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THE SHEFFIELD SCIENTIFIC SCHOOL OF YALE UNIVERSITY

A SEMI-CENTENNIAL HISTORICAL DISCOURSE

OCTOBER 28, 1897

BY DANIEL C. GILMAN

Sometime an officer of the School and now President of the Johns Hopkins University

NEW HAVEN
PUBLISHED BY THE SHEFFIELD SCIENTIFIC SCHOOL
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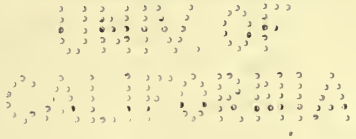

NEW HAVEN
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I SHOULD BE THE LAST TO FORGET OR DISPARAGE THE SERVICES OF UNKNOWN BENEFACTORS. THESE HAVE IN A LARGE DEGREE MADE LIFE FOR US WHAT IT IS. THESE HAVE THEIR OWN COMMEMORATION WHEN WE RECALL THE PROGRESS OF THE AGES.

BUT THERE ARE OTHERS WHO STAND OUT AS LEADERS, AS REPRESENTATIVES. GIFTS, LABOURS, THOUGHTS OF DISTINGUISHABLE ANCESTORS GO TO SWELL OUR SPIRITUAL PATRIMONY. IT MAY HAVE BEEN BY SOME CONSPICUOUS WORK WHICH WAS NOBLY SPREAD OVER A LIFETIME; IT MAY HAVE BEEN BY SOME SWEET TRAIT WHICH WAS JUST SEEN IN A CRISIS OF TRIAL; BUT "HERE AND THERE" THEY HAVE HELPED US, AND IF WE ARE TO ENJOY THE FULNESS OF THEIR SERVICE, WE MUST SOLEMNLY RECALL IT.

IN DOING THIS WE ARROGATE TO OURSELVES NO AUTHORITY OF FINAL JUDGMENT BY GRATEFUL CELEBRATION.

—*Bishop Westcott.*

Press of The Friedenwald Company, Baltimore, Md.

HISTORICAL ADDRESS

This is the hour for congratulation and recollections. It is our privilege to look backward over the path of half a century and to trace the steps, often slow but never devious, by which the penniless, nameless and homeless offspring of an ancient and vigorous stock has attained commanding influence, rich in possessions, beloved by thousands of followers, honored wherever known, and still with the fresh enthusiasm of youth, aiming at lofty ideals, attractive as the face of nature, varied and comprehensive as the laws by which this world is governed.

It would be easy, and it might be profitable, to engage in an exclusive commemoration of those who have made this institution, and to bring forward reminiscences of incidents and events—some of them truly romantic—which illustrate the progress of its remarkable life; yet the dignity of this assembly, the presence of so many persons from a distance, and the relation of the Sheffield School to higher education in the United States forbid such limitations. You must therefore permit me to give a subordinate place to those sentiments which are uppermost in our hearts—congratulations mingled with affection and gratitude, and with vivid memories of those who have departed—while I

try to do justice to their wise and assiduous labors by showing their relation to the times and to the progress of science in the latter half of the nineteenth century.

If the Antiquary should now appear, you would be sure to remember that his task had already been well performed; and if I should assume the garb and chisel of Old Mortality, you might remind me that the moss has not yet gathered upon the inscriptions in yonder cemetery. While Argus and Briareus, the one for the University and the other for the School of Science, are on the alert, it requires some assurance to traverse the annals which they have collected; and yet this discourse must be historical. So in face of difficulties, enhanced by the distance which has separated the speaker from these once familiar scenes, from muniments and archives, I enter upon the duty of the hour, conscious of the honor received from your courtesy and grateful for an opportunity to stand once more among former colleagues, pupils and friends.

To a returning wanderer, it is a delight to see this favored university renewing its youth, at the approach of its second centennial anniversary—more comprehensive, more useful, more liberal and more worthy than ever before of loyal affection and support.

Eighteen hundred and forty-seven is the year of our nativity. But there was a pre-natal existence worth remembering. Truly, Yale College has always stood for Science, and therefore it is no wonder that those who initiated the department of Philosophy and the Arts, just after President Woolsey assumed the chair, had faint notions of the importance of their proceedings. They were quite unconscious of developing new forces.

Mr. Bryce, in his sketch of the Holy Roman Empire, remarks that the year A. D. 476, which schoolboys are taught as one of the most important dates in everybody's chronology—the downfall of the Roman Empire —was no such date to those then living as it has since become, nor was any impression made on men's minds commensurate with the real significance of the event. So it is in our academic chronology. As conclusive evidence, recur to this modest announcement originally made in the Catalogue of 1847:

"It has long been felt at Yale College to be important to furnish resident graduates and others with the opportunity of devoting themselves to special branches of study, either not provided for at present, or not pursued as far as individual students may desire." Accordingly the department of Philosophy and Arts is established. By this simple decree the system of graduate studies now in vogue throughout the land was formally inaugurated. Moreover an inconspicuous postscript states that "Professors Silliman and Norton have opened a laboratory on the College grounds for the purpose of practical instruction in the applications of science to the arts and agriculture."

Thus was born the Sheffield School, with the inheritance of an opportunity, a desire, a hope and a belief, supported by an empty purse and slight expectations.

> "That primal age which did as gold excel
> Seasoned its acorns with keen appetite
> And thirst to nectar turned each springing well."

To illustrate the evolution of this idea, then first produced among us, to show what ingredients it included,

what unexpected nurture it received, what storm and stress it survived; especially to show that this idea was planted in fertile soil by the spirit of our age, the *Zeitgeist*, believing and delighting in the study of nature and her laws, we must consider the state of mankind in the middle of the nineteenth century, and the conditions of liberal education then prevalent in the United States and England. No milestone marks the transition from the old to the new, yet the older men in this assembly are conscious that this is a very different state of society from that of 1847. The education, the creeds, the industries, the commerce, and of course the science and the arts of civilized countries are changed. This is a freer, busier, wealthier, more complex, and indeed a wiser and happier world than that of our fathers—before the gold of California and Australia and the diamonds of South Africa had been discovered, or the magic spark, flashing over land and sea, had transformed the usages of domestic life and the processes of international intercourse; or the life-giving agencies, the heaven-sent blessings of anæsthesia and antisepsis, had removed from the bed of pain, apprehension and distress.

It was the middle of this century when the doctrine of evolution, which has pervaded every branch of natural history, and extended its influence to medicine, anthropology, sociology and history, was publicly set forth, a period, as a recent historian has shown, in which a doctrine that may be traced to Empedocles, Heraclitus and Aristotle, found "its perfect expression" in the writings of Charles Darwin. On the evening of July 1, 1858, a day almost as memorable as that when the

island of Guanahani was revealed to Columbus, the epoch-making papers of Darwin and Wallace were read to the Linnaean Society of London; but it should not be forgotten that, sixteen years before, Darwin had written out a sketch of the Origin of Species, and with wonderful self-control had kept it in his portfolio while he gave eight patient years to the study of barnacles. We have the authority of Sir Archibald Geikie for saying that the two geological chapters in the Origin of Species produced the greatest revolution in geological thought which has occurred in our time. It was in 1860, when Herbert Spencer announced the programme of his philosophical system; but nine years earlier he had printed a volume entitled "Social Statics, or the conditions essential to human happiness specified and the first of them developed." Lyell had been for a long while the leading authority of England in the science of palæontology, but the startling book in which he demonstrated the antiquity of man did not appear until five years after the publication of the Origin of Species. This is not the place to discuss the far-reaching and all-pervading influences which proceeded from these writings, nor to dwell on the controversies they evoked, such as those with which we are familiar between Agassiz and Gray, but I bring these instances forward as indications of the extraordinary intellectual vitality of the middle of the nineteenth century and of the changes in human thought of which this school has been the watchful observer.

I have the authority of an eminent naturalist for saying that "The most significant aspect of this movement is the general recognition, by all thoughtful men, of

the proof which was afforded, by the progress of discovery, of the truth that the unity of all nature is orderly, and discoverable by scientific methods."

In the domain of physics, changes have occurred almost as remarkable. The doctrine of the conservation and correlation of forces, beginning with a determination of the mechanical equivalent of heat, was suggested and developed between the years 1842 and 1862 by Mayer, Grove and Joule. Faraday was then at the zenith of his powers, Helmholtz and Kelvin at the outset of their illustrious careers. But it was as far back as 1830 when Joseph Henry, then a schoolmaster in a country town, reached those discoveries in electromagnetism which made the telegraph a proximate certainty and brought into the intercourse of mankind a revolution almost as great as the primitive invention attributed to Cadmus. Spectrum analysis, that powerful agency which reveals the constituents of incandescent bodies, even the chemical and physical nature of the remotest stars, was then unknown.

Likewise glance at mathematics and astronomy fifty years ago. Laplace had been dead for over twenty years; Gauss was living in an advanced age; Sir Wm. Rowan Hamilton had announced but had not published the new calculus—Quaternions—which was to give him high rank with the greatest mathematicians; Cayley, Sylvester, and Hermite were at the portal of those investigations which have made their names illustrious in the science "which never takes a backward step." The abstract reasonings of such men are beyond the apprehension and appreciation of minds non-mathematical; but this is not true of astronomy, for every human be-

ing, the wayfarer and the shepherd, as truly as the philosopher, is interested in the progress of celestial science. No purely scientific discovery within our memory has made such an impression on the popular mind as that of the planet Neptune, whose existence, foretold by Adams and Leverrier, was demonstrated on the night of September 23, 1846. Then the astronomer of Berlin turned his lens, by request, to the predicted place, and first recognized as a planet that vast orb which had been circling in solemn silence for countless ages thousands of million miles from the sun. This superb achievement, like the torch bearer of Aurora's car, was the precursor of a long series of splendid additions to astronomical science, as well as of great improvements in the telescope and of great endowments for astronomical research.

But unexpectedly a new astronomy has supplemented the old, and celestial physics is standing side by side with celestial mechanics as the interpreter of the mysteries of the universe. Surprising as was the revelation of Neptune, wonderful as are the maps of the heavens, and the calling of the stars by their names, it is more remarkable that astronomy can now tell us the constituents of every heavenly body. This is the triumph of spectrum analysis, already mentioned, the contribution of chemistry and physics to astronomy, an inevitable evolution from the researches of Kirchhoff and Bunsen, in 1859.

I am in danger of multiplying these fascinating allusions, and of trying to give in a single page an abstract of a cyclopædia, which would be the task of Icarus, predestined to fall; but mention must be made, if it be

only with a word, of recent advances in some other departments of science. Think of geology including palæontology on one side and petrography on the other; of chemistry, with its revelation of new elements, leading up to the Neptune-like discovery of Argon, and with its innumerable contributions to agriculture, metallurgy and pharmacy, to color, food and flavor; of engineering and mechanics with their acquired control of force and matter, in ordnance, ships, dynamos, engines, bridges, tunnels and air ships; of the sciences of metallurgy, meteorology, geodesy, exploration, navigation and aerostatics. It is truly a half century of marvels proceeding from the patient, unrequited, unseen pursuit of science by men of extraordinary ability and of absolute concentration on the advancement of knowledge. By common consent, it is the age of electricity, and the history of that single branch of science verifies a saying of Faraday's, which was early adopted in this school, "There is nothing so prolific in utilities as abstractions." But every science has made its contributions to the advancement of the race, and every advance has made more obvious the mystery of existence and increased the humility of man as he thinks of that which transcends his reason.

> As "knowledge grows from more to more,"
> So "more of reverence with us dwells."

Different minds will place different estimates on the intellectual accomplishments of these recent years. In ordinary conversation the men of the mart will point to an Eiffel tower, a suspension bridge, a continental express train, a man-of-war, an Atlantic cable, or a great

exhibition. On the other hand scholars of the lamp, like Freeman, will give precedence to the comparative method of study now employed in history, language, politics, economics and religion. But in this assembly may I suggest that perhaps the greatest triumphs of the intellect during the last half-century are these five contributions to human knowledge: The establishment of the principles of evolution; the establishment of the principle of the conservation of energy; the development of mathematical science and its application to physics, mechanics, electricity and astronomy; the development of spectrum analysis and the consequent discoveries respecting light and electricity; and the discovery of the nature and functions of bacteria, and of their influence, for weal or woe, upon living organisms.

To these may be added, perhaps, the birth of experimental psychology, a child so young that though it seems to belong to the family of Hercules, its strength has not been fairly tested.

It is time to turn from the aspects of science to those of education. Prior to the days of Faraday, Darwin and Huxley, of Agassiz, Dana and Whitney, the classics held their sway and controlled with almost absolute supremacy the liberal education of England and the United States. The benefits of instruction in Latin and Greek, enormous as they were, received exaggerated praise, in spite of the dictum of Sir Wm. Hamilton, which was often quoted, that nothing brought the classics into such disrepute as requiring them of every student. To enforce this statement it is not necessary to appeal to the opponents of classical culture. The words of a renowned scholar, distinguished for his

knowledge of antiquity and his love of the ancient landmarks, tell the story well. The classical revival, says Freeman, "in all its forms and stages, fostered the idea that the languages, the arts, the history of Greece and Rome at certain stages of their being, were the only forms of language, art and history which deserved the study of cultivated men. It led to the belief, not perhaps fully put forth in words, but none the less practically acted on, that those two languages, and all that belonged to them, had some special privilege above all others—that the studies which were honored by the ambiguous name of 'classical' were fenced off from all others by some mysterious barrier—that they formed a sacred precinct which the initiated alone might enter and from which the profane were to be jealously shut out. Such a state of feeling, a feeling which has even now far from died out, could not fail to lead to mere contempt, and thereby to mere ignorance of everything beyond the sacred pale. And what is more, it hindered any knowledge of the true nature of those things which were allowed a place within the sacred pale. It led to a cutting off of so-called 'classical' studies from all ordinary human pursuits and human interests."

To a very considerable extent this reproach, if it is a reproach, is likewise American. The opportunities, the honors, the pleasures and the rewards of a liberal education were opened during the first half of this century to those only who had been disciplined in the ancient languages, and this discipline was continued through the greater part of the subsequent non-elective curriculum. To verify this remark it is only necessary to examine the catalogues of the leading colleges of this

country during the first five decades of this century, or to read the defense of classical studies annually printed by Yale College for twenty-five years prior to 1854. Spasmodic efforts were made for the foundation of new courses, but virtually West Point and Troy were the only established places in this country for good technical instruction so late as 1847. Whitney was so conscious that the men of letters, in the group to which he belonged, depreciated the aims and objects of scientific education that he wrote a pamphlet which silenced, if it did not remove, the prejudices of all who read it. Its reperusal at this time is invigorating.

But for twenty years previous to 1847 a force had been at work in a little country town of Germany destined to affect the education of Christendom; and at the same time to enlarge the boundaries of human knowledge, first in chemistry and the allied branches, then in every other one of the natural sciences. The place was Giessen; the inventor, Liebig; the method, a laboratory for instruction and research. Dr. Welch has lately reviewed in an address at Philadelphia the results which proceeded from this innovation of a genius.

Another event contributed to the expansion of education. About the middle of the century the first World's Fair, held in London, had revealed to English-speaking people the increasing supremacy of continental nations in those branches of industry which depend upon the applications of science. The British were alarmed. The papers of the day, and especially the London *Times*, were vigorous in calling for improved methods of public instruction, and especially for the better guidance of chemists, miners, engineers, geologists and manufactur-

ers, for all who aspired to be leaders in the technical pursuits upon which the prosperity of the British Empire depended. Hence in close connection, though not in this order, came the department of science and art and the museums at South Kensington, the great provincial colleges of science, the Cavendish laboratory at Cambridge, the new museum at Oxford, and other noteworthy advances. From that day to this scientific education in England has been making progress, although Germany and France and other continental states still hold their ascendency; for now, as then, the laboratories of those countries and the abundant encouragement given to scientific research by their governments excite the admiration of our mother country and ourselves.

Is it not apparent that in the middle of this century responsibility for the advancement and diffusion of knowledge was wider and deeper than ever before? Imbued by this spirit of the times, Smithson made his famous bequest, soon to be followed by similar and greater gifts from others, a splendid line of endowments, which has spread with advancing civilization from Massachusetts Bay to the land of the Golden Gate.

Geographical discoveries, previously confined to islands and coasts, or to narrow lines in desert or barbarous countries, now began to assume continental magnitude. Earth, air and sea, and even celestial space, were called upon to reveal their secrets. The importance of accurate measurements having now been completely established, instruments of precision became more perfect, complex and varied, produced by a noble army of inventors who never dishonored the drafts which were made by science on the bank of mechanical ingenuity.

Mathematics formed a close alliance with construction and invention. Improvements in lenses, and their mountings, as shown in telescopes, microscopes and many other -scopes, and the invention of concave gratings, were among the fruits of this alliance. Astronomy, physics, mechanics and engineering renewed their strength. Natural history went beyond the limitations of system. Publications were multiplied; new associations were formed, national and international. Specialization took the leadership, and before Humboldt died, the era of general scholarship was past, the new era was fairly under way.

In all this progress the dominant note has been the advancement of science and not the accumulation of wealth; truth and not personal gain. Why did Darwin and Dana engage in intellectual toil in the intervals of physical disability? Why did Faraday abandon "commercial work" at the moment when it promised great returns? Why had Agassiz "no time for money making"? Certainly not because they despised the ease of life, but because personal gain was nothing compared with the study of nature and the advancement of knowledge. Wisdom was more than gold. Moreover, an unselfish desire to enlarge the welfare of mankind has been a powerful stimulus to the ablest men. If I name the discoveries of anæsthetics and antiseptics, with the subordinate yet very significant evolution of cocaine, the applications of electricity, the improvements in hydrography and in navigation, and the growth of preventive medicine and the science of hygiene, and the alleviations of surgery, you will be reminded that science repays with ample usury the advances made to her account.

In this splendid epoch of intellectual progress, brilliant and memorable as the revival of letters, the early days of the Sheffield School were passed. An alchemist looking on might have asked what philosopher's stone could produce that amount of the precious metals which would be indispensable for the success of a school devoted to such aims; but his brother, the astrologer, casting the horoscope, would have replied that resolution can do more than gold, and enthusiasm than much fine silver.

Thus we reach the conclusion that this celebration is significant, because, among the institutions created during the last half century for the promotion of scientific research and education, the Sheffield Scientific School of Yale College has held an honorable place. It is this relation to the progress of human development that gives importance to the day of small things and dignity to transactions, which by themselves might be insignificant were they not governed by enlightened views, so presented, advocated and maintained that their influence has been powerful.

As I proceed to speak of the organization of this school I shall not attempt to distribute the laurels among those who took the leading parts, but one of them, Benjamin Silliman, long the scientific Nestor of this community, dear "Uncle Ben," admired and honored, is entitled to our first grateful mention, not only because of his power of interesting the public, and his perseverance in maintaining the American Journal of Science, but for his personal instruction, during many years, of unenrolled young men who enjoyed the limited opportunities of his primitive laboratory and the bene-

fits of a great, then unrivaled, collection of minerals. Silliman had prepared the way for the School of Applied Chemistry, and Woolsey becoming president of the college, fresh from studies abroad, caused the scheme to be so broadened that it became the Department of Philosophy and the Arts, akin in scope and spirit, though not equal in resources to the great foundations of Europe, like Bonn, Göttingen and Berlin, with which he was familiar. It must have been a great satisfaction to the revered ex-president, nearly thirty years afterwards, to utter, on a public occasion, these words, doubly valued by his hearers, because they came from one who knew the circumstances and from one who was always guarded in the bestowal of praise. "From the first," he said, "the professors have struggled against probabilities. They have worked by faith. They have aimed to have a school, sink or swim, worthy of the science of this country. As a result, I think there is, confessedly, no other school of this character, in this country, which is on a level with this. I would give equal honor to the devotion of the professors and to the munificence of the giver."

Here let me remind you of a fact not generally known though clearly recorded. As far back as 1814 resident graduates were enrolled as a distinct class on the Yale catalogue, and in 1819 and 1820 the numbers so enrolled were thirty and thirty-one. This shows that the beginning of graduate studies in this University antedates by more than thirty years the department of Philosophy and the Arts.

In 1846, two young men, devoted to applied science and ready for careers, were made by Yale "university

professors." It is a striking coincidence, that Harvard and Yale, generous and friendly aspirants for the leadership, caught the laboratory quickstep at almost the same time. The gift of Abbott Lawrence, made in 1847, led at once to the appointment of the great Agassiz and almost immediately to the opening of a chemical laboratory, organized by Professor Horsford, a pupil of Liebig.

One of the two young professors at New Haven, having an inherent love of agriculture, and an excellent preparation in Edinburgh and Utrecht, was qualified to direct a chemical laboratory and to give instruction in the sciences pertaining to agriculture. Professor John P. Norton was fully possessed by the spirit of modern science and soon gathered around him a company of young chemists, some of whom were destined to win the highest distinctions, three of them still students, colleagues and teachers, now present with us, strong in attainments, influence and character, stronger still in the affection of their pupils.

The second of the original appointments was that of Benjamin Silliman, Jr., a man of enthusiasm and energy, and of boundless hospitality, intellectual and social, whose name and address, quick sympathies and interest in applied science gave promise of great usefulness. The labors of both these men were soon interrupted. One was diverted to other fields of activity in Louisville and New York; the other died at the threshold of his fame. I have often thought what a difference it would have made if the school had then been endowed. Norton, trying to do double work at Albany and New Haven, fell a victim to the exposures of winter

travel; and Silliman was led to seek remunerative occupations elsewhere. Those were the days of which Lounsbury thus speaks: "The college had no money to give, but even if it had it is more than doubtful if it would have given it. No one at that time, however enthusiastic, ever dreamed of the supreme importance which the natural sciences were soon to assume in every well-devised system of education. The impression prevailed that chemistry, like virtue, must be its own reward."

The youth of this school was spent like a foundling's, its future was precarious. At length, new forces came to its support. Certain obstacles, elsewhere encountered, made it easy for Professor William A. Norton to bring to Yale his classes in civil engineering, and he was followed by his colleague, Professor John A. Porter, then devoted to chemistry. These appointments were invigorating. Norton was an admirable teacher, well trained at West Point, painstaking, accurate, thorough, well acquainted with the progress of his favorite science and always commanding students of ability. Porter, who had been a pupil of Liebig, was a man of letters as well as of science, a poet, philosopher and patriot, thoroughly believing in the New Education, as President Eliot named it, and ready to enlarge by the various influences at his command the scope of the Scientific School, of which he became for several years the able and eloquent exponent.

Rapid growth followed, due chiefly to one man whose name, before all others, is on our lips as the founder of this school, Joseph E. Sheffield. It is needless to recount the steps from a gift of five thousand dollars to the amount of a million, with which we are familiar.

Naturally, the school looked up to him as a father, and asked permission to bear his name. He consented with reluctance, but he never forgot the child once adopted, and in the final distribution of his estate, made it equal with his sons and daughters. The year of christening was 1860.

Mr. Sheffield was a man whom future generations, like the present, may delight to acknowledge and honor as a founder. Nothing will ever be revealed about him that his school will wish to cover. On the contrary, if those who knew him best would utter what they know, the world would admire even more than it does now the sagacity, the modesty, the consideration and the unselfishness of our great benefactor. His liberality grew with the growth of the school. It was shown in little things and in great; in the payment of current bills, in the provision of large funds. "I get my reward every day as I look out upon that workshop," was the answer that he made to an expression of gratitude. "No investment pays me so well," was another of his remarks. "I wish you to bear in mind," he once said to Professor Brush, "that you have never asked me for a dollar." Yet with all this growing interest, and with his readiness to listen to all the inside history of the school, he never to the slightest degree interfered with its affairs. He trusted the governing board. He knew more intimately than any member of the corporation, the plans, the wants, the success and the limitations of the school, and to the utmost of his ability he contributed to its maintenance. An intimacy which continued for more than twenty years between the chief executive of the school and its nearest friend was never

clouded by a moment's disagreement. His only regrets were the limitations of his resources. To all these engaging traits must be added the remembrance of his strong intellect, his comprehensive charity, his integrity, gentleness and faith. Happy the school that can bestow love as well as gratitude upon the memory of its chief benefactor.

Such example was contagious. No one was surprised when neighbors, townsmen and friends at a distance, one after another, in many successive years, enlarged the endowment. Farnam, the life-long colleague of Sheffield; Norton, the father of the agriculturist; Wheeler, an enthusiastic graduate; English, senator and governor, promoter of studies in law, history and science; Phelps, whose gateway adorns the campus; Winchester, founder of the Astronomical Observatory, who, like "the embattled farmers" at Concord, has "fired a shot heard around the world," and whose widow has given to the school one of its most important halls; Collier, who perpetuated, by a fund, the memory of his departed brother; and a lady of Liverpool, Mrs. Higgin, who established a professorship; besides Fellowes, Boardman, Sampson, Dodge, and many more. By their encouragement the school was doubly strengthened, for during the lifetime of its chief benefactor every such gift brought another from him. Since his day, the munificence of Mrs. Winchester and the bequest of Mr. Fayerweather are indications that new friends have arisen to strengthen these foundations.

The relations of the school to the State began after the Federal Government, by the Morrill Act of 1862, distributed among all the states a certain amount of

land-scrip for the promotion of scientific education. Connecticut gave the income of its portion to the Sheffield, and although the amount annually received from this source was not large, it seemed so, and was accepted as a token of public confidence most timely and encouraging. This disposition was good for the State and good for the College, and fully justified the action of Governor Buckingham and those who concurred with him in advocating this appropriation. A long line of governors from his time onward testified to the value of such an arrangement. Its termination, after almost thirty years of harmonious union, is much to be regretted among the unfortunate annals of divorce.

Soon after the reception of this grant, several members of the faculty entered upon an educational campaign which can hardly be brought to mind, in a retrospect of this long interval, without provoking a smile at the enthusiasm of youth and at the "expulsive power of a new affection." The principal towns of the State were visited, and the chief men of the tribes were assembled to hear of the new education. Sometimes in lecture rooms, frequently in private parlors, once in a court house, once in the Governor's room at Hartford, and once in a fire-engine room, the story was told with the earnestness of conviction, if not with the graces of eloquence, and with the certainty not of history but of prophecy. Dana, a constant friend, had inaugurated the campaign some years before by a public address. Whitney's "Aim and Object" was distributed freely as a campaign document, and the newspapers, always responsive to the claims of the school, echoed these pro-

fessorial utterances in villages and by-ways. The school did not reap much money from the farms or mills, but it made hosts of friends, whose favor has never departed. One of the most valued was the revered Horace Bushnell, and Governor Hawley was another.

But why should further extracts be read from the book of Chronicles? Let us rather consider the significance of the circumstances, gifts, sacrifices, labors, methods and suggestions which have made the Sheffield School.

From the beginning onward this institution has been a department of a university, of a university which never suffered its love of letters to blind its eyes to the value of science. In the days of closely restricted income, during the first half of the century, chemistry, mineralogy, geology, botany, mathematics, physics, meteorology and astronomy were taught in Yale. Nor will any one think that scientific research was undervalued if he recalls the preparation of Dana's Mineralogy, the light that was thrown on meteoric showers, the studies of the aurora, and of the zodiacal light, and the search for an intra-mercurial planet. Very different would have been the Sheffield record if it were not associated with the fame, the fortune and the followers of a greater alma mater. Substantial advantages were bestowed by the mother upon her child—the use of the library and of the cabinets of mineralogy and geology. The Peabody Museum, the Winchester Observatory, with its far-famed heliometer, and the Street School of the Fine Arts shed their light like the sun, on all the university, but the gift of George Peabody especially

contributed to the growth of a school in which mineralogy, geology and zoology were prominent subjects of instruction.

Still Sheffield has not been held by the leading strings of its mother. It has had a large amount of independence. Its funds, buildings, appointments have been its own. The professors have been its governing board, controlling its courses and its funds, subject to the oversight of the President and Fellows. On one occasion, at least, the faculty asked permission of the astonished corporation to reduce their own salaries, and the request was granted!

Thus it has come to pass that no "conflict of studies" has been heard of; no hostility between science and letters; no "warfare" between science and religion. The Sheffield School has always stood for the idea of a liberal education in which scientific studies should predominate, but in which a moderate amount of Latin and of modern languages is required; history and economics are also taught. It is memorable that for a long period the greatest of American philologists was the daily instructor in French and German; and that the most learned study ever made of "Dan Chaucer and his well of English undefyled" proceeded from a Sheffield chair; and that no American professorship of economics or statistics has been more prolific and stimulating than that which was held for many years by one but lately brought to the end of his career.

Slight perturbations in the academic and scientific orbits might interest a great astronomer, like Newcomb, but to the ordinary observer they were as imperceptible as the influence of Neptune upon Uranus.

Dr. Michael Foster, the English physiologist, in a recent address has called attention to the fact that the increment of human knowledge transcends the power of man to assimilate it. This is most obvious when a course of preliminary education is considered. So many subjects are said to be "of the first importance," so many are "indispensable," that, like new wine in old bottles, they have burst the curriculum of our fathers and overtaxed the capacities of youthful recipients. Elective systems, costly, vexatious and antagonistic to time-honored traditions, must now be provided in every college and institute of technology. It is one of the glories of the Sheffield that from the beginning students have here been permitted to choose a group of studies, the constituents of which were beyond their choice. "Freedom, under control," has been the rule of the house. Moreover these groups have not been set forth as professional courses, but as ladders leading up to special callings, as preliminary to modern professions and technical pursuits. One of the most advantageous of these courses has been preliminary to medicine. To follow the healing arts, which have made during the last half century such wonderful advances, discipline is requisite in physics, chemistry, physiology, with prolonged laboratory practice and increasing familiarity with the normal functions of organic life. Such courses were projected here five and twenty years ago, and gradually the medical colleges are discovering their value. The Johns Hopkins Medical School, for example, allows no student to enter as a candidate for its four years' course unless he has had such a training, substantially, as that here offered many years ago, and

never so advantageously as now. Names might be cited of eminent physicians, leaders in physiology, pathology, physiological chemistry and hygiene, who received their bent from the preliminary medical course of the Sheffield School.

In the matter of Degrees, it is not possible to distinguish between the requirements of the school and those of the department of Philosophy and the Arts, nor is it important, for the greater includes the less. Certainly Yale and Sheffield are entitled to the credit of introducing among American institutions the degree of Doctor of Philosophy, demanding for it a high standard of attainments, and never bestowing the honor (not in a single case, so far as I can remember) by any irregular promotion. This degree has proved a powerful incentive to scholarship in this and other universities, and the list of *laureati Yalenses*, beginning, in 1861, with three distinguished names, soon followed by one of the highest renown, is a list to be proud of. It is also noteworthy that the school has never yielded to the American tendency to multiply the forms of the baccalaureate degree, a multiplication almost as bad as tampering with the coins of the realm.

A large amount of freedom has been given to the students outside of the halls of learning. Twice an application was made for places at daily prayers in the college chapel, for scientific students; but none were provided, doubtless because the building by tradition and in construction was a collegiate and not a university chapel, and not because the scientific students were considered "past praying for." There has been no common table, no dormitory, no regular general assem-

blies of officers and students; on the other hand there have been no rebellions against authority, no disorder, no hostility toward the faculty, no apparent trend toward irregular life, no lack of college spirit.

In the annual catalogue for many years the same phrase has been employed to express the object of the Sheffield School. These are the familiar words:

"The Sheffield Scientific School is devoted to instruction and researches in the mathematical, physical and natural sciences, with reference to the promotion and diffusion of science, and also to the preparation of young men for such pursuits as require special proficiency in these departments of learning."

By these double services this school is known. Indeed, if you would estimate the value of any institution of learning, measure its breadth and its depth; its breadth as revealed in the number, distribution and attainments of its pupils, by their success and renown; its depth, as shown by contributions, direct and indirect, made by its faculty and graduates to the advancement of knowledge.

There is no recent statement of the occupations of Sheffield graduates; but the brief phrases of the triennial, and an extended personal acquaintance, in places near and remote, justify the following assertions. Nearly two thousand men have here been graduated and many more have been well trained, according to their aptitudes, in science and in the applications of science to the useful arts. Many of them have proceeded to higher degrees, or have entered at once upon places which led up to a participation in the construction of public works, the conduct of industrial estab-

lishments, the charge of mills, mines, surveys and explorations, and the promotion of public health. Others, and some of the ablest, have entered upon the study of medicine. A large number have been called to chairs of instruction and investigation.

The earliest list of graduates was prognostic. Six of the seven Bachelors of Philosophy became teachers, one a geologist and an explorer of the western territory, one the botanist of the California Geological Survey, and a third one of the leading mineralogists of the world. Go to South Africa or to Japan, or to Turkey, to California or any of the trans-Mississippi States, inquire into the work of the United States Geological Survey, scan the membership of the National Academy of Sciences, look at the faculty of Yale, of the Massachusetts Institute of Technology, and of many other colleges, and you will come at once upon the Sheffield men.

As an example of their activity, a most interesting story might be appropriately told, if the time would permit, respecting the adventures of a graduate of 1862 and his friend, in crossing the continent before the first Pacific Railroad was built, of their map of the Yosemite, and of their mountaineering in the Sierras, which culminated in the ascent of Mount Whitney. Then came the celebrated exploration of the fortieth parallel, and the subsequent organization of the United States Geological Survey, of which this distinguished scholar became the first director. Such achievements belong to the trophies of the school.

It is never easy, in a public assembly, to review the progress of science or to estimate individual achievements. Many important contributions have no char-

acteristics which are of interest beyond the circle of experts, or even intelligible. The speaker is certainly disqualified from making such a review or from weighing in a critical balance the services of the able men, his personal friends, who have constituted the faculty. Their presence may forbid him to utter their names; yet he ventures to recall some facts which are known even to the inexpert and to allude to others which the modesty of the faculty might be disposed to hide.

I only allude to the vast contributions made to science, in four of its branches, by James D. Dana, and to the extraordinary scholarship and fertility of William D. Whitney, lest I appear to be claiming for a part of the philosophical department that which belongs to the whole. The professorships which they held—due to one honored benefactor—were independent of the Scientific School. But no one should forget that Dana was for years enrolled on the list of the Sheffield instructors, that his lectures and field excursions were always attended by Sheffield students, and that the impulse given to the school, from 1855 onward, was largely due to the encouragement and co-operation of this great naturalist, whose personal strength was fortified by his position in the college faculty. Nor can we fail to remember that Whitney, a scholar of distinction among the scholars of the world, was the daily teacher, the constant adviser, and the unfaltering believer in the Sheffield School.

You have been reminded that the analytical laboratory, in the old white dwelling house ("the lab" of our college slang), was the first, and for a time the only "outward sign of inward grace" which was shown by

the new school; even now the manifold activities of five great buildings do but magnify the importance of their elder departed brother. With increasing vigor and undiminished enthusiasm, the laboratory study of chemistry there begun has been prosecuted for fifty years, partly for its own sake and partly because of its relations to agriculture, mineralogy, metallurgy and physiology.

Consider agriculture. These are the days when everybody is conscious that the welfare of the country, perhaps the stability of the government, is dependent upon "the crops," but not everybody remembers when he sees the heavily laden trains, the well filled elevators and the wharves burdened with wheat, cotton and tobacco, that the national supplies are largely results of advances made by science. Every State in the Union now has its college of agriculture and the mechanic arts. It was not so when Norton came to Yale. He was a pioneer in the scientific agriculture of the United States; and with a longer life would have accomplished much more; for he knew how. He set the pace. When his mantle fell upon Porter, a student of Liebig's, twenty-six leading agriculturists, from every part of the country, were brought to New Haven, for a conference of many days, and it would not be difficult to show that this unique, primeval example of university extension had a powerful influence in promoting, on right principles, the study of agriculture. This was in 1860. It was estimated that five hundred persons from a distance came here to follow more or less of these lectures and discussions. Consequently, came the national grant, associated with the name of Senator Morrill, an enact-

ment due in no small degree to influences here put forth. From this congressional bounty, Cornell, Madison, Minneapolis, Berkeley and other universities of the Western States derive a considerable part of their revenues.

A pupil of John P. Norton's soon took the leadership in agricultural chemistry, and no one has outstripped him in the race. His books, his suggestions, his scientific memoirs, his researches, and his personal influence have made the school famous. The list of his publications is a long one, but it is more remarkable when tested by qualitative than by quantitative analysis. One of them, "How Crops Grow," is almost as widespread as the vegetation it describes. Like the Pilgrim's Progress, it is adapted to every clime. Early in the seventies the author began to advocate the establishment of Experimental Stations, and in due time had the satisfaction of seeing them established throughout the Union, while he became director of that in Connecticut. This achievement alone reflects great distinction on the Sheffield School. If it had done nothing but make and uphold this idea, its cost would have been repaid.

Closely associated in the promotion of scientific agriculture has been a different sort of mind, one whose unfailing resources, practical sense, and varied knowledge sometimes overshadow his ability as an investigator in four important branches of science. He was long a wanderer on the Pacific slope, collecting plants and experience, climbing mountains and difficulties; but he returned to New Haven at the regeneration of the school in 1864-5 and his post-exilian studies have

been directed to heredity, the evolution of breeds and the transmission of acquired characters, and to the conditions of public health.

New Haven has been a centre of mineralogical enquiry during the entire century. Its collections, which began with the famous candle box of Professor Silliman, were augmented by the cabinet of Colonel Gibbs, and have grown into the varied and comprehensive possessions of the Peabody Museum. These collections inspired the renowned treatise of James D. Dana, whose work has been extended and made more complete by able followers connected with this school. Important contributions to the science of mineralogy, involving a great amount of accurate discrimination, were modestly put forth year after year by the director of the school as supplements to Dana's work. New localities were visited, and old localities were revisited always with good results, not only in beautiful specimens, but also in positive contributions to science. His absorbing administrative duties have not dimmed his enthusiasm nor abated his energy. He is one of those men, rare at any period, who carry on the most special investigations in their own domain, while they show a broad sympathy with other workers, and a great capacity for perception, suggestion, encouragement and aid.

So in geology. Able investigators whose observations and publications have been important have gone hence to other institutions; but there is among us an illustrious and world-renowned investigator who has never been enticed away as a professor, but who as an explorer penetrated regions before unknown in the far West, and who brought from them treasures as marvel-

ous as if he had carried in his hand the lamp of Aladdin. As a scientific writer, he has surpassed himself as a scientific explorer; for these brilliant discoveries were interpreted with masterly ability and patience, and have been put before the world in the best of form, chiefly at his own expense. The fossil horses, Hippus, and his more ancient precursors, with their two toes, three toes and four toes, ancestors of the racers of to-day, and his "birds with teeth," have become classical illustrations of the evolution of higher animals and are famous; but it is not so well known that a thousand species of extinct vertebrates have been brought to light by this great discoverer, many of them of the highest significance in their lessons and suggestions.

The study of zoology has been renovated during the history of his school. The value of classification has not depreciated, while that of embryology, morphology and physiology has become more apparent. The senior biologist has extended his operations over a vast area and to the uttermost depths of the ocean. Modest, learned, patient and thorough, he has described the marine fauna whose existence has been brought to light by systematic dredging. One hardly knows which is the more wonderful, the limitless numbers or the varied structures of new species which he has introduced. An able colleague, concentrating his attention upon the crustacea, though not exclusively, carries on and extends the investigations which gave to Dana no small part of his early renown.

Nor was zoology the only department of natural history here promoted, for a chief authority in one branch of botanical science, including ferns and sea-weeds, was

here distinguished as a collector and writer. This day his name is inscribed upon a tablet placed with his books and herbarium in a memorial room.

In the various branches of engineering science, civil, mechanical and dynamical, the school has always maintained a high reputation. Long ago, the head of this department investigated with ability, ingenuity and patience the nature of comets and the principles of molecular and cosmical physics; and at an earlier time, he made an important series of investigations upon the set of wood and metals after transverse stress.

In later days, another accomplished West Pointer, who is said to have been the first to suggest the cantilever bridge, was distinguished for his work upon steam generators and other prime motors. They were followed by other able engineers who were skillful in the advancement of their science, as well as in its applications. One of them has produced a treatise upon strains in framed structures (not to speak of his other writings), which is everywhere accepted as an original authority.

Whatever else is omitted from this imperfect sketch, I must not fail to remind you that improvements in the instruments of research are among the most important possible contributions of ingenious men to the advancement of knowledge, and that an improvement has here been made in the manufacture of lenses—those powerful agents in every field of optical enquiry—by one who was once a student and is now a professor in this institution. By a masterly study of the mathematical laws, and a practical application of those laws, which called at first for extraordinary patience, methods of

producing lenses were devised which have been pronounced successful by a company of eminent astronomers, and have been widely adopted.

Physiological chemistry is one of the latest additions to the subjects here taught. At once, in this department, the School has risen to the foremost place. Nowhere else in this country, not in many European laboratories, has such work been attempted and accomplished as is now in progress on Hillhouse Avenue, unobserved, no doubt, by those who daily pass the laboratory door, but watched with welcoming anticipation wherever physiology and medicine are prosecuted in the modern spirit of research.

The younger workers in this corps may say that the speaker is not as familiar with the doings of these later years as he is with those of an earlier day. Unquestionably this is so; but there is this consolation, that another voice, at another time, will then do them ample justice. *Seniores ad honores, juniores ad labores.*

The review to which you have now listened has suggested a gallery of portraits which ought to be etched by some Rembrandt of the pencil or the pen before the characteristics are forgotten. At the gateway of Trinity College, Dublin, stand the figures of Edmund Burke and Oliver Goldsmith; in the ante-Chapel of Trinity College, Cambridge, the statues of Isaac Newton and Francis Bacon. I would not compare our worthies with those of any other college or ask for them all the portraiture of marble and bronze; but I would emulate the example so common in old countries of honoring in the places of their activity illustrious men. Not to mention those now living, how many pairs there are whose por-

traits might be pendants. Tablets, busts, paintings or etchings should be placed in honor of them all.

Whitney and Dana, well described by the Master of the House in his memorial discourse, are entitled to distinction as philosophers both, renowned throughout the world; John P. Norton and Benjamin Silliman, Jr., the two young chemists who perceived so distinctly the needs of the times; William A. Norton and John A. Porter, who invigorated the school in a critical moment by their presence and their instructions; Lyman and Trowbridge, promoters of the mechanic arts, able to apply their mathematical abilities to practical affairs; Eaton, the lover of nature and the interpreter of hidden laws of life; and Walker, the far-famed economist and statistician, the soldier and the patriot—all these have gone over to the majority, leaving the School rich in the remembrance of their abilities, services, influence and devotion. Three of the earliest class that graduated are still connected with it, strong, honored and rewarded for life-long adherence to noble ideals. Around them are scores of juniors, just as vigorous, just as hopeful, just as gifted as those by whom they have been taught. May gratitude and honor reward them all.

I have lately heard this story. A certain king, instituting a brotherhood, promised all who would join it, marble monuments which should be placed in rows upon the sides of an aisle. "A hundred years hence," he said, "you will see that the effect will be fine." "Thank your majesty," said one of the brothers, "the King will doubtless be here then, but I shall not." Sons, brethren and fathers, one hundred years hence many

monuments will adorn our halls and avenues. The effect will be fine. We shall not be here to see them, but the school, our sovereign, will be, and great will be the satisfaction.

By this course of remarks you have been reminded that this school was founded in favorable environs, at a propitious time, and also that it is only one of many kindred agencies initiated within the period under review. The Lawrence Scientific School of Harvard was almost coeval. In quick succession, colleges, departments of science and independent institutes have appeared in every State. Of these, not a few have adopted the methods here followed or have called to their support those who have here been trained. For one such institution, now celebrating its majority, permit me to acknowledge with filial gratitude, the impulses, lessons, warnings and encouragements derived from the Sheffield School, and publicly admit that much of the health and strength of the Johns Hopkins University is due to early and repeated draughts upon the life-giving springs of New Haven.

This fellowship of scholars is one of the greatest satisfactions that the teachers, graduates and students of a college can enjoy. Many of us are aware that we are but lay brethren, servitors or postulants, in the temple of science, disclaiming even the title of scientific men; but every one of this concourse of students must be conscious that he has dwelt among the brethren, and that he can perform a part, though it be a very humble part, in upholding and applying the principles that this school inculcates and for which it stands.

We are enlisted, commissioned officers and privates,

in an army which is not restricted to provincial recruits, and which carries light arms and heavy ordnance. Far and wide throughout the civilized world; in obscurity and poverty, or in stations of affluence and influence; alone or in companies; with complex engines and penetrating lenses, or with the unaided powers of masterly brains; now searching the depths of earth or ocean, now watching the stars in their courses, now bending over the microscope, the blow-pipe, the alembic, the comparator or the spectroscope; and now engaged in abstract reasonings, wondering that these mathematical relations have been so long concealed; often disappointed or led to merely negative results, and yet sometimes encouraged by an addition to science or by the perception of a law hitherto unobserved—in all their diversity of powers and occupations, a noble corps is engaged in overcoming Ignorance, that omnipresent foe, and the destructive cohorts that Ignorance leads. Fear, superstition, bigotry, error, misery, weakness, pain and sloth are put to flight by this array of wisdom against folly.

It gives courage to remember that the work of each generation is continuous with that of the past. The departed are with us. Thought as well as matter is indestructible. As the long list of philosophers, from Pythagoras and Aristotle to Isaac Newton, the great apostle of modern science—*qui genus humanum ingenio superavit*—prepared the way for the achievements of the nineteenth century, so men now living are heralds and pioneers of discoveries and conquests dimly foreseen or faintly foretold. Therefore it is not strange that while the note of anxiety and despondency is heard in other spheres, no pessimistic cries proceed from our

ranks Slowly, steadily, surely the stately column marches on, "never resting, never halting." Victory follows victory: light penetrates darkness: Health, Temperance, Enjoyment, Virtue and Piety follow knowledge.

Finally let me say, with the solemnity of deep conviction, that dearer than the fellowship of brethren, deeper than the love of knowledge, too precious to be ever given up, too sacred for careless speech, is the invigorating and inspiring belief that Science in its ultimate assertions echoes the voice of the living God.

You have traced the evolution of an idea; you have seen how it has come to pass that in Yale, as in other universities, mathematical, physical and natural science receives ample recognition. At first, in the Sheffield, chemistry was alone; engineering soon found a place; mathematics, physics and astronomy joined the oligarchy; in due time, mineralogy, geology, physical geography, zoology, botany and physiology found a welcome; modern languages and literature, history and economics, became strong allies. Not a word was spoken in disparagement of classical culture, nor a word of religious controversy.

You have heard the story of humble beginnings, gradual expansion, lofty ideals, personal sacrifices, munificent gifts, public services, abundant rewards; and also of well-founded hopes, looking forward to a second half-century of life and growth. Can I close with words more suitable than those of Laplace, as he reviewed his long life:—*Ce que nous connaissons est peu; ce que nous ignorons est immense.*

While I spoke thus, the seedsman, Memory,
Sow'd my deep furrow'd thought with many a name
Whose glory will not die.

—*Alfred Tennyson.*